CARNIVOROUS PLANT NEWSLETTER

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Front Cover: *Nepenthes masoalensis*, 5 m a.s.l., Masoala Peninsula, Antsiranana. Photograph by Eric Schlosser. See article on page 100.

Back cover: *Roridula dentata* cultivated at the University of Connecticut EEB Conservatory (Storrs, Connecticut), from seed from Heuningvlei, Western Cape, South Africa. Inset is flower in midwinter. Article on page 106. Photograph by Matthew Opel.

Carnivorous Plant Newsletter is dedicated to spreading knowledge and news related to carnivorous plants. Reader contributions are essential for this mission to be successful. Do not hesitate to contact the editors with information about your plants, conservation projects, field trips, or noteworthy events. Contributors should review the "Instructions to Authors" printed in the March issue of each year. Advertisers should contact the editors.Views expressed in this publication are those of the authors, not the editorial staff.

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Notes on some little known carnivorous plants from Madagascar

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Keywords: travelogue: *Drosera*, Madagascar, *Genlisea margaretae*, *Nepenthes masoalensis*, *Utricularia*.

Introduction

Madagascar has a high rate of endemism thanks to the early separation from the mainland (Gondwana). Sixteen percent of the 500-1000 plant genera and 79% of the 5500-6100 plant species in the eastern part of the island are exclusively found in Madagascar (White, 1983).

Although wealthy in biodiversity, the natural areas in Madagascar are highly threatened by human activity. Southeast Asians were the first people to colonize Madagascar, arriving approximately 1000-2000 years ago. With them came deforestation and abusive land practices causing desertification and astronomic rates of erosion that can be seen today. Presently, less than 9.9% of the vegetation remains relatively untouched, and Madagascar scores highly among the eight hottest hotspots for endangered biodiversity (Myers, *et al.*, 2000, Brummitt & Lughadha, 2003).

Surprisingly, the carnivorous plants of Madagascar are not as isolated as might be expected. While many species have been described for the country, most were subsequently identified as being species already discovered and described. *Drosera burkeana, D. natalensis, D. indica,* and *D. madagascariensis* occur as well in continental Africa (Keraudren-Aymonin in Humbert (ed.) 1982). Of the 19 species of *Lentibulariaceae* in Madagascar, none are endemic. One of these is a species of *Genlisea—G. margaretae*—and the rest are *Utricularia;* comprising the terrestrial *U. caerulea, U. bisquamata, U. firmula, U. welwitschii, U. arenaria, U. livida, U. folveolata, U. prehensilis, U. scandens U. appendiculata, U. subulata*; and the aquatic *U. benjaminiana, U. cymbantha, U. foliosa, U. gibba, U. inflexa, U. reflexa,* and *U. stellaris* (ordered according to Taylor (1989)). The only carnivorous plant species confined to Madagascar are *Drosera humbertii, Nepenthes madagascariensis,* and *N. masoalensis.*

Sea Shore Forest: Andranoanala

Within walking distance from the village of Ambodirafia on Madagascar's eastern cape is an area that hosts some of the threatened littoral forest. This parcel (la Parcelle détachée d'Andranoanala) was declared part of the Parc National de Masoala, mainly to protect one of the few occurences of *N. masoalensis*. *Nepenthes masoalensis* was described as a new species by Schmid-Hollinger (1977). It can easily be identified by the cylindrical upper pitchers (see Front Cover), whereas the closely related *N. madagascariensis* has typically funnel-shaped upper pitchers. *Nepenthes masoalensis* may be the most ancestral species, because it has the lowest number of nectar and digestion glands. The intermediate pitchers of *N. madagascariensis* are similar to upper pitchers of *N. masoalensis*.

N. madagascariensis is found in swamps along the east coast from Tolagnaro (James, 1988) to Maroansetra on the western side of the Masoala Peninsula (Schmid-Hollinger, in Humbert, 1982). The distribution of *N. masoalensis* is limited to a few coastal localities on the Masoala Peninsula in north-eastern Madagascar (Lecoufle 1985). It is estimated that there are less than 2500 adult *N. masoalensis* plants left, therefore it has been added to the IUCN's Red List as endangered (Clarke *et al.*, 2004). The forests of this area are still relatively undisturbed, but the isolated parcel is highly threatened by escaped fires that may result from "tavy," i.e. Malagasy for the common agricultural practice of slash and burn. In fact, signs of recent burns are found inside the park.

After our arrival at the airport of Antalaha, the nearest city, I was surprised to be welcomed by a botanically accurate painting of *N. masoalensis* on the wall of the waiting hall. We rented a Renault 4 for the time consuming drive towards the park. This small but popular car, known as

"quadrelle", has the reputation to be able to go anywhere. The next day, we waited some hours until we finally asked for the guide; a hilarious request since it was raining cats and dogs, but we had a packed time schedule. The heavy rain was disturbing, because we had already gotten our car stuck in the sandy road on the way here, and that was on a dry day—chances were, the road on the way back would be impassable. But as soon as the guide arrived the sun came out! During the so-called "dry season" the rain is unpredictable.

We passed village fields and crossed a shallow river where *U. arenaria* and *U. subulata* thrived in the occasionally flooded grasslands bordering the river. *Utricularia arenaria* is closely related to *U. livida*, but is much less variable. Another sterile aquatic bladderwort was casually observed but not identified due to our hypochondriacal fear of Schistosomiasis (Bilharzia, a serious disease spread by flukes carried by snails) and cowardice of crocodiles.

We entered the littoral forest on foot, but our progress was often interrupted by having to climb or otherwise bypass trees felled in March 2004 by an extremely destructive cyclone ("Gafilo"), which also devastated 95% of Antalaha. *Nepenthes masoalensis* was found to be locally abundant in a small area. Unlike the forest farther inland, seashore forest grows on sand, and is influenced by tidal water levels, but not by salt water. Here it supports a stand of short trees (including *Pandanus* sp.) and heather (Ericaceae); the *Nepenthes masoalensis* thrived in the forest openings. The *Nepenthes* displayed healthy growth with both very nice green upper pitchers with sometimes red lids. The winged uniformly brown-red lower pitchers were attached to very long straight tendrils, hiding among the leaf litter on the ground. Only few old, dried up, male flowers were seen. Insects seemed to prefer munching on the leaves of the accompanying vegetation instead of the *Nepenthes* plants.

The maintenance of the park is poor because only few tourists visit and there is no money to keep the track clear. Development is hindered by the frequent cyclones that destroy the infrastructure (for example accommodations, roads, and bridges; the two largest rivers can only be crossed by unmotorized ferries). Only few basic accommodations exist. On the other hand, tourists with a tight budget will enjoy a romantic, wooden, *Ravenala*-covered bungalow. For two persons it was rented out for as little as 3000 Ariary (ca. 2 US$) per day, which included candle light, bucket shower with water brought from a hole dug near the beach, and hand sized spiders all around.

Falling Water: Marojejy

After our safe return, we continued to Sambave, the world capital of vanilla production, where we arrived covered with brick-red dust from the road construction. We passed several military checkpoints that try to control the organized crime that comes with the high price for vanilla. Our next destination was the Marojejy range, located in north-eastern Madagascar, about 50 km from the Indian Ocean. These mountains compete with Masoala for the highest precipitation rate in Madagascar. They receive more than 3000 mm (120 inches) of rain annually. Marojejy is the only remaining large mountain range of Madagascar that has all four of the major Madagascar zones of vegetation types intact. Outside the reserve, the forest has been transformed into an overexploited, agricultural area. The pressure on the remaining forest inside the reserve is great.

Marojejy is in a national park, open to all paying visitors, and is managed by the Association Nationale pour la Gestion des Aires Protégées and the World Wildlife Fund. The trailhead can quite easily be reached taking advantage of a taxi brousse from Sambave towards Andapa. A 'taxi brousse' is a good place to get in contact with the locals. However, this van sized vehicle for shared transportation offers little comfort, because it is stuffed with no less than 20 to 30 people (plus luggage on the roof).

The park has a bad reputation for being infested with leeches and can only be accessed by walking 4 to 5 hours from the road. Each day we met only a handful of people. Our ascent was made during the dry season (mid-September), but in this area, no month is really dry. While on the mountain it rained one way or another the entire time. It was windy and cold (5-9°C) near the summit; here the night time lows may be just above 0°C during winter. Many tourists visit the rainforest exclusively to observe lemurs, endemic monkey-like animals with fluffy fur that perform acrobatic jumps high above the forest floor or stare back at the tourists with beady eyes. The white silky sifaka (a diurnal lemur) was a rare sight, but the other Malagasy fauna (chameleons, shiny green millipedes and a good number of bird species) were routinely spotted.

The trail to the summit was eventful, and involved fording two rivers without bridges, crawl-

Figure 1: *Drosera humbertii*, 2100 m a.s.l., eastern summit of Marojejy, Antsiranana.

Figure 2: *Utricularia livida*, 1400 m a.s.l., central highlands, Antananarivo.

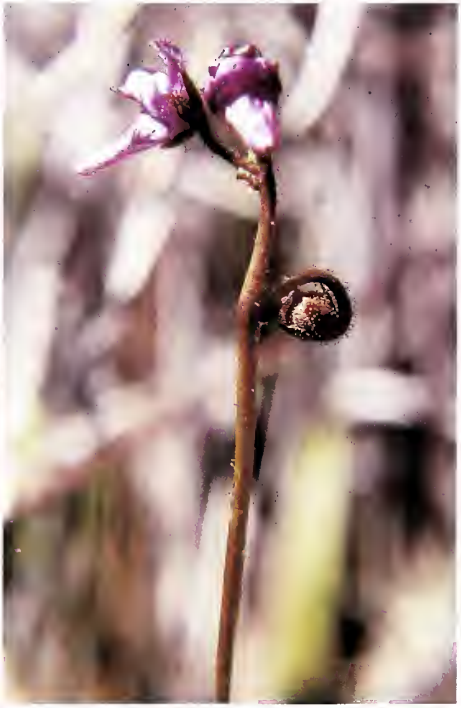

Figure 3: *Genlisea margaretae*, 1400 m a.s.l., central highlands, Antananarivo.

ing under fallen tree trunks that blocked the path, jumping from root to root with the eroded forest floor some feet below, and hanging onto branches or roots where the trail was very slippery and steep. After three days hiking in the rain, my perpetually water-filled boots started to fall apart. Maybe I will wear sandals next time, as did our guide.

Little has changed from the time of Henri Humbert, a French botanist who was the first to scientifically explore the nature in this area in 1955. As we ascended the park mountains, the land changed from cultivated fields to evergreen rainforest (75 to 900 m a.s.l.), then to mountainous rainforest (up to 1400 m a.s.l.), and sclerophyllous (i.e. lichen- and moss-covered) montane forest (up to 1800 m a.s.l.), that suddenly gave way to the treeless montane shrub of the summit. Even the weather was the same as Humbert reported: clouds and rain.

The first carnivorous plant was encountered at Camp Marojejya at 800 m right behind the open-air-kitchen: a medium sized *D. madagascariensis* accompanied by a green flowered orchid (*Habenaria* sp.) was growing where water seeped down the steep gneiss-escarpment. Farther down, the river banks were covered with an unidentified species of *Utricularia*, most likely a large form of *U. livida*, that was just about to send up some flower spikes.

However, I was impatient and very curious to see the little known *D. humbertii*, that is reported from isolated mountain tops at 1400-2130 m a.s.l.. The guide hesitated to make the ascent to the summit because of the rain. But the unpleasant climb was rewarded by the interesting vegetation and finally the discovery of *D. humbertii*. It turned out to grow prolifically in wet spots on quartzite silt and in seeps among grasses, sedges, and needle or scale leaved ericoid vegetation all the way from 1800 m to the mountain top. *Drosera humbertii* has been compared to *D. capensis* (Exell, 1956), because it has a superficially similar growth habit and leaf shape. But its laciniate stipules, almost smooth scapes, and smaller, but robust constitution set it clearly apart. *Drosera humbertii* is known to form rather woody stems (3-7 cm), but some plants reaching an impressive length of up to 20 cm were found (see Figure 1). The compact growing tip often has only 3 to 7 active leaves (ca. 2 cm long), the older ones bend down, soon decaying, revealing the bald stem. Other caulescent *Drosera* from tropical Africa (*D. bequaertii, D. madagascariensis, D. katangensis, D. affinis, D. elongata*) have thinner stems and an increasingly more elongated growth in order to compete with the surrounding vegetation (Degreef, 1990). Considering the temperatures, the compact growth and the length of the stem, it is not unlikely that the tall *D. humbertii* were already growing there when Humbert visited this place. But old growth like this was rather the exception and frequently many young plants were found. No flowers and very few old scapes were present. Only a few plants were about to develop scapes; these emerged laterally from the rosette, then curved to become erect. The flowering season for this species as well as for many orchids is November to March (i.e., the wet season).

Very few compact rosettes of *D. natalensis* were also found. In Madagascar this species was often erroneously identified as *D. burkeana*. But the latter is not as common in Madagascar; it has suborbicular leaves and ovoid seed while in *D. natalensis* the leaves are spatulate and the seed is ellipsoid-fusiform (Exell, 1956). *Drosera humbertii* is clearly not merely *D. burkeana f. angustifolia*, nor is it a hybrid between *D. madagascariensis* and *D. burkeana* (or *D. natalensis*) as suggested by a note on the type herbarium sheet. *Drosera humbertii* has broad petioles like *D. natalensis* and an upright growth and leaves not quite as long as in typical *D. madagascariensis*, but the leaf shape is very different (linear, elongated lamina), not intermediate. *Drosera madagascariensis* was last seen at 1200 m and *D. humbertii* is a common *Drosera* near the summit.

Humbert also collected *U. gibba* (Manantenina) and *U. appendiculata* (Marojejy), the latter being unique among the *Utricularia* species because its climbing scapes twine in the opposite circular direction from all other species. While *Utricularia* was found whenever it was wet and open, often alongside the path, only two types of flowers were observed: Between 1400 m and 1900 m a few green flower scapes, approximately 15 cm tall with pale purple-bluish corollas were seen. The lower corolla rims were flat (*ca.* 12 mm broad), the palate raised, with two crests and a central yellow blotch. A second kind of seape with pale violet flowers and darker centers on the lower lips were found flowering sparsely near the summit. These had upper corolla lips that closed over the white rimmed palate. The scapes were *ca.* 5 cm tall and green near the base, turning bright red towards the flowers. The two types of flowers were very different from each other, and while they were found in several locations they were not very variable. It took a while studying Taylor (1964) to conclude that they are both one and the same species: *U. livida*, but apparently very different from the commonly cultivated forms. *Utricularia livida* is well known as an easy to grow, happily

flowering, cute little bladderwort with a remarkable distribution (Africa and Mexico). In the field it is very variable and known to have forms restricted to some mountains that appear to be distinct. Almost a dozen taxa were described from Madagascar alone, but found synonymous with *U. livida* (Taylor 1964).

Water of Life: Andranovelona

Another eye-catching, surprisingly large flowered form of *U. livida* was found after our return to the capital and a two-hours drive northwest from Antananarivo, within the central highlands of Madagascar. Its strangely long scapes (40 cm) reached high above the grass, and they moved so much in the wind that taking photographs of their crowded inflorescences was nearly impossible (see Figure 2). This plant, with long curved spurs, was first listed as *U. spartea* by Perrier de la Bathie (1954). The corolla is homogeneously violet-blue with the exception of a small yellow blotch on the palate, and another white stripe along the center of the lower corolla.

Two more species of *Utricularia* were found in flower. The first was a very small, typical *U. subulata* with a few yellow flowers and many seed capsules on zigzag scapes approximately 4 cm tall. The second species was more interesting, with longer peduncles, but even smaller purplish flowers with bright yellow palates. Determining the identity of this plant was difficult. The few flowers present were malformed, but as some of the scapes were twining, I supposed it was the form of *U. welwitschii* that was described as *U. aberrans* by Bosser (1958). But after reading Bosser's original publication it became clear that the corolla of this form of *U. welwitschii* is more extremely reduced in size. *Utricularia firmula* has small flowers and a long curved spur, however it invariably has a yellow corolla (Taylor, 1989). The only remaining described species that this could be is *U. bisquamata*. The scapes were quite long, but based upon the corolla size it certainly is not the giant form reported from the northwest of the island (Taylor, 1989). It was also unusual in having a long acute spur (which, by the way, is also found in the giant form from South Africa). No traps were seen, but the seed shape (ovoid, smooth, slightly reticulate) finally confirmed this being *U. bisquamata.*

An isolated occurance of *Genlisea margaretae* was refound at this special location in 1988 (Klotz, 1991; Fischer, 2000). Formerly classified as a new endemic species (*G. recurva*) by Bosser (1958), its original collection site was found destroyed in 1973. *Genlisea margaretae* is an uncommon species that is closely related to the smaller *G. glandulosissima*, and the two species are known to hybridize in Africa (Taylor, 1991). Both have seed capsules on strongly recurved and densely glandulous pedicels (see Figure 3). However *G. margaretae* has taller scapes (15-35 cm) that are almost glabrous, unlike the evenly gland-covered scapes of *G. glandulosissima.*

Numerous compact rosettes of *Genlisea margaretae* with densely packed scale-like leaves were found, most of which were flowering and setting seed. The treeless vegetation in the area is mostly specialized to very dry conditions (xerophytic). Carnivorous plants were confined to the watercourse, with the highest concentration of plants occurring where water seeped onto smooth stone outcrops. The ecotone between light brown grassland (*Fimbristylis* sp.) and grey granite was highlighted by red *D. madagascariensis*; a good indicator where the other more elusive species could be found. This botanically interesting site certainly deserves a higher grade of protection.

Conclusions

On one hand side I wished the national parks were more frequented by tourists so more money would be at hand to protect these ecosystems, increase park-related employment, and to buy the appreciation of the local population who would rather like to use these areas for agriculture. On the other hand, I was very glad to see that the remote areas we visited were not yet spoiled by heavy tourist-traffic. Transportation and infrastructure was surprisingly good, but certainly not meeting western standards. I enjoy remembering this very special vacation: altogether eleven carnivorous plant species were observed in their unique natural habitats, and some in unexpected places such as the ponds next to the famous baobab alley near Morondava. I also fondly remember the friendly people and excited children calling out, "Salu vasaha," which means "Hello stranger!"

Permit notes: None of the travels reported in this paper required special permits to enter sensitive areas.

References

Bosser, J. 1958. Sur deux nouvelles Lentibulariacees de Madagascar. Nat. Malagache 10: 22-29.

Brummitt, N. and Lughadha, E. 2003. Biodiversity: Where's hot and where's not. Conservation Biology 17 (5), 1442-1448.

Clarke, C., Cantley, R., Nerz, J., Rischer, H. and Witsuba, A. 2000. *Nepenthes masoalensis*. In: IUCN 2004. 2004 IUCN Red List of Threatened Species. <www.redlist.org>.

Degreef, J.D. 1990. *Drosera* caulescents d'Afrique. Dionée 20.

Exell, A.W., and Laundon, J.R. 1956. New and noteworthy species of *Drosera* from Africa and Madagascar. Boletim Socied. Broteriana, sér.2, 30: 213-219.

Fischer, E., Porembski, S., Barthlott, W. 2000. Revision of the genus *Genlisea* (Lentibulariaceae) in Africa and Madagascar with notes on ecology and phytogeography. Nord. J. Bot. 20(3): 291-318.

Humbert, H. 1955. Une merveille de la nature à Madagascar. Première exploration botanique du Massif du Marojejy et de ses satellites. Mém. Inst. Madag., Sér. B 6: 1-272.

Humbert, H. (ed.) 1982. Flore de Madagascar et des Comores. Muséum National d'Histoire Naturelle, Laboratoire de Phanérogamie, Laboratoire de Phanérogamie, Paris: 41-62.

James, G. 1988. Some Observations of a Population of *Nepenthes madagascariensis* in Madagascar. Carniv. Pl. Newslett., 17: 102-103.

Klotz, S., Köck, U.-V. 1991. Neufund von *Genlisea recurvata* auf Madagascar. Willdenowia 20.

Lecoufle, M. 1985. A la découverte du *Nepenthes masoalensis*. Dionée 5.

Myers, N., Mittermeier, C.G., da Fonseca, G.A.B. and Kent, J. 2000. Biodiversity hotspots for conservation priorities. Nature 403: 853-858.

Perrier de la Bathie, H. 1954. Revision des Lentibulariaceae de Madagascar. Mém. Inst. Madag. Sér. B 5: 187-200.

Schmid-Hollinger, R. 1977. A new *Nepenthes* species from Madagascar, *Nepenthes masoalensis sp. nov*. Bot. Jahrb. Syst. 97(4): 575-585.

Schmid-Hollinger, R. 1979. Die Kannenformen der westlichen *Nepenthes*-Arten. Bot. Jahrb. Syst. 100: 379-405.

Taylor, P. 1991. The Genus *Genlisea*. Carniv. Pl. Newslett., 20: 20-33.

Taylor, P. 1989. The Genus *Utricularia*. Kew Bull. Add. Ser. 14: 725pp.

Taylor, P. 1964. The Genus *Utricularia* L. (Lentibulariaccae) in Africa (south of the Sahara) and Madagascar. Kew Bull. 18: 1-245.

White, F. 1983. The AETFAT chorological classification of Africa: history, methods, and applications. Bull. Jard. Bot. Natl. Belg. 62: 225-281.

Roridula, a carnivorous shrub from South Africa

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Keywords: carnivory, cultivation — *Roridula dentata*.

Introduction

The southwestern corner of South Africa, in the vicinity of Cape Town, is home to a remarkably diverse assemblage of plants called the Cape Floral Kingdom. Into an area covering only 0.04 percent of the Earth's land are crammed 8500 species of plants (Cowling & Richardson, 1995), most of which are found nowhere else in the world. The center of one racetrack, for instance, is home to four endemic plant species (Cowling & Richardson, 1995). The Cape Floral Kingdom is also the exclusive habitat for six endemic plant families, including one of special interest to students of carnivorous plants, the Roridulaceae.

Roridula, the only genus in the Roridulaceae, consists of two species of woody shrubs whose leaves are covered with sticky hairs. *Roridula* plants look rather like sundews glued to the end of sticks. *Roridula dentata* (see back cover; a small but mature plant in spring, about 75 cm tall) is a richly branched shrub that can grow as tall as a person, while *R. gorgonias* is a somewhat smaller plant with fewer branches.

Roridula, like many of the unique plants of the Cape Floral Kingdom, is a component of fynbos: a scrubby South African vegetation type that grows on impoverished soils in areas with warm, dry summers and comparatively cool, rainy winters. Fynbos is subject to—and in fact dependent upon—periodic fires that clear the land and force most plants to start again from seed every 4-60 years (van Wyk & Smith, 2001). With its scarcity of nutrients and open habitats maintained by fire, fynbos is an ideal habitat for carnivorous plants. Indeed, moist sites, such as seeps on the sides of mountains, are home to many bladderwort and sundew species, including the prolific terrarium favorite *Drosera capensis*.

Given its habitat—streamsides and other damp spots in fynbos—and the fact that its gummy leaves ensnare copious insects, you might conclude that *Roridula* really *ought* to be carnivorous. In fact, Gardiner & Jenkin (2004) report that *R. dentata* has even been known to capture small birds! Darwin (1875) considered the possibility that it was insectivorous, having observed entangled insects on the leaves of a herbarium specimen. However, Darwin also observed that glandular hairs on *Roridula* herbarium specimens were never folded over captured animals. Observations of living plants confirm that the leaves are not capable of movement in response to prey (pers. obs.), unlike the flypaper-leaves of the undoubtedly carnivorous *Drosera*. It has also been established that *Roridula* does not secrete enzymes to digest insects that get stuck (Ellis & Midgley, 1996), and the tendency has been to classify it as a mere sub-carnivorous plant. According to this view, the primary role of the sticky hairs is to deter herbivores; any benefit to the plant from the nutrients of decaying, trapped insects was thought to be incidental.

Revisiting the Non-Carnivorous Classification of *Roridula*

Recent findings have caused botanists to reconsider the case for carnivory in *Roridula*, and the evidence now seems to be in favor of including it among the elite ranks of true flesh-eating vegetables. Ellis & Midgley (1996) fed *R. gorgonias* with flies that had been artificially enriched with an uncommon isotope of nitrogen (isotopes are forms of a chemical element with differing atomic masses), and found that the plant was absorbing nitrogen from trapped flies. Subsequent experiments (Midgley & Stock, 1998; Anderson & Midgley, 2002; Anderson & Midgley, 2003a) tried to identify the sources of nitrogen for *R. gorgonias* and *R. dentata* plants growing in the wild, by making use of the convenient fact that different sources of nitrogen have different ratios of naturally-occurring isotopes. As it turns out, both species obtain up to 70% of their nitrogen from insects; by this measure, plants in the genus *Roridula* are as carnivorous as the *Drosera* species that grow nearby!

How can it be that *Roridula* is so dependent upon captured animals for its nutritional needs, when

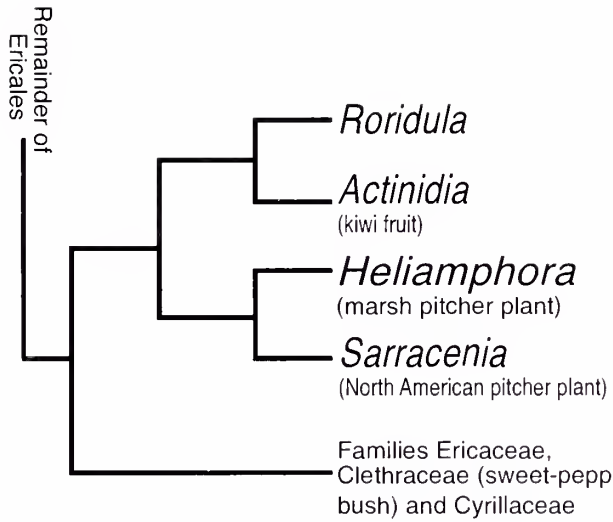

Figure 1: Evolutionary tree showing relationships of *Roridula*. The Roridulaceae is sister to the Actinidiaceae, and together these families are sister to the Sarraceniaceae. Tree topology after Anderberg *et al.* (2002).

it has no ability to digest prey? The explanation is that the plants have a symbiotic, mutually beneficial relationship with assassin bugs (Anderson & Midgley, 2003a). Each species of *Roridula* has its own species of assassin bug (*Pameridea marlothii* on *R. dentata*, and *P. roridulae* on *R. gorgonias*). The bugs, using a method not yet understood, are able to navigate the flypaper-like leaves without getting caught themselves, and indeed are not found anywhere besides *Roridula* plants. Assassin bugs are carnivorous, and must live the life of Riley on shrubs that catch their supper for them. Of course, *Roridula* is not providing free bug food out of the goodness of its heart, and it is the excretions of the assassin bugs, absorbed directly through the leaves, that provide the plants with all of that insect-derived nitrogen. So, as with certain pitcher plants that rely on bacteria to digest their prey, *Roridula* performs the work of digestion using associates.

Further complications in the symbiotic relationships of *Roridula* have recently been elucidated. *Pameridea* is not only the key to the insectivorous habits of *Roridula*, but also an important pollinator for the plant. Juvenile assassin bugs move pollen around within flowers, and ensure that *Roridula* sets some seed through self-pollination even when more mobile pollinators like bees are scarce (Anderson & Midgley 2003b).

Recently, it has been discovered that *Roridula dentata* is also the exclusive home to a specialized spider, *Synaema marlothi* (Anderson & Midgley, 2002). Like *Pameridea* bugs, *Synaema marlothi* is somehow immune to the plant's glue. Through field observations and comparisons of nitrogen isotopes in *Roridula* plants with varying levels of spider activity, it has been determined that the spiders not only scavenge insects caught by *Roridula*, but also prey upon the assassin bugs! However, the spiders provide little nitrogen to the plant, perhaps because they do not defecate on the leaves (Anderson & Midgley, 2002).

The sticky hairs—with which *Roridula* actually catches the insects that provide it with a significant part of its nitrogen needs—have some peculiarities of their own. I have grown *R. dentata* in a greenhouse for several years, and one of the most striking things about the plants is their proficiency at catching insects, everything from fungus gnats to houseflies, yellowjackets and even dragonflies. I have never seen a bird captured, but then, birds hardly ever get into the greenhouse. The adhesive that the glandular hairs produce is resinous and tacky; different from, and apparently far more powerful than the mucilaginous secretions of *Drosera* or *Pinguicula*. It makes the plants somewhat unpleasant to work with, actually, as the slightest contact results in smears of water-insoluble, dirt-attracting *Roridula* gunk that can persist on the hands for days unless a concerted effort is made to scour it away. Even the largest insects are efficiently immobilized by the glue on *Roridula* leaves. It has occurred to me to try placing a *Roridula* outside, near a bird feeder, but the probable result of such an experiment would be

more grotesque than enlightening. It would, however, be quite interesting to observe whether the assassin bugs on wild *Roridula* attack the birds that are sometimes captured, and determine if the plants benefit from vertebrate prey.

Foraging Strategies

It is clear that *Roridula* captures, kills, and benefits nutritionally from insect prey, but does it have any specific adaptations to attract insects? Some preliminary observations suggest that it does. Midgley & Stock (1998) studied *R. gorgonias* and determined that its leaves and stems are strongly reflective in ultraviolet wavelengths of light. This characteristic is commonly associated with plant organs that attract insects, such as flowers, and the traps of carnivorous plants. More work clearly needs to be done in this area: *Roridula dentata* should be tested as well, and the UV reflectivities of both species ought to be compared to the reflectivities of neighboring carnivorous and non-carnivorous fynbos plants.

I have noticed another characteristic of *Roridula dentata*, not recorded by previous authors, that also might be a means of attracting insect prey: the plants are fragrant. The smell of *Roridula* is subtle but distinctive. It is strongest on sunny, warm days, when a sensitive human nose can detect a large plant from several meters away. The fragrance is not associated with the flowers (which are odorless), nor is it produced as a result of crushed leaves or other damage. Many other plants of the fynbos have pungent odors that result from compounds thought to prevent herbivory (Cowling & Richardson, 1995), but the sweet fragrance of *Roridula* is different. Artificial vanilla pudding is the closest analogue I can suggest. A sweet smell constantly emitted by a carnivorous plant suggests a role in luring prey, but many questions remain. Are South African insects attracted to this odor? What are the volatile chemicals responsible, and do they mimic the chemicals that attract pollinators to the flowers of other local plants? Can osmophores (scent-producing secretory structures) be identified in *Roridula* leaves? Does *R. gorgonias* have a fragrance, and how does it compare to *R. dentata*? It is too early to speak with any certainty, but there are strong indications that *Roridula* is adapted to attract insect prey by smell as well as by sight.

Whence *Roridula*?

Having determined that *Roridula* has as many adaptations to carnivory as some canonical carnivorous plants, we might next ask: Is *Roridula* related to any other group of flesh-eaters? The answer is yes, but probably not to the group you are thinking of. The family Roridulaceae shares the flypaper-type trapping mechanism found in certain genera of the Lentibulariaceae (butterwort family) Byblidaceae (rainbow-plant family) and Droseraceae (sundew family), and has even been considered to be part of the last two at one point or another (Moore, 1993). However, differences in the details of the trap—e.g., mucilaginous vs. resinous glue—suggest that resemblances to the Roridulaceae might be superficial.

The modern consensus is that the Roridulaceae is unrelated to any of the other carnivorous families with flypaper traps, and instead is firmly placed in the order Ericales, which comprises about 25 families, including the eponymous Ericaceae (rhododendron family) (Anderberg *et al.*, 2002). Indeed, if you have handled rhododendron flower heads and gotten gummy secretions all over yourself, you have a good idea of what the resin in *Roridula* is like. A study of the order Ericales using comparisons of DNA sequences, suggests that the closest living relative of the Roridulaceae is the Actinidiaceae (kiwi-fruit family) (Anderberg *et al.*, 2002). The *Roridula*/kiwi branch of the tree of life is next to the branch for the Sarraceniaceae (New World pitcher plants) (see Figure 1). While these groups share some morphological characters, these are microscopic or embryological features, and are not obviously related to carnivory. For now, it seems that the Roridulaceae and the Sarraceniaceae evolved their insect-trapping strategies independently. It is interesting to note, however, that these two carnivorous families and their relatives in the Ericaceae are typically plants of nutrient-poor, acidic soils, a habitat specialization that may have created a favorable milieu for the acquisition of traits involved in carnivory.

Raising *Roridula*

The cultivation of *Roridula* is not easy. As is the case with any recalcitrant plant, of course, there

is a set of conditions where *Roridula* will thrive and reproduce without any care whatsoever: the conditions in its natural habitat. Providing some reasonable approximation of these conditions under glass has proved to be difficult, at least where I live, in the northeastern United States. Below are some notes on my experiences with *R. dentata*. I have not grown *R. gorgonias*, but most of what I say should be applicable to that species, as well.

Before attempting cultivation, it is instructive to consider the native range of a plant. *Roridula dentata* is restricted to an area northeast of Cape Town, centered in the Cederberg ("cedar mountains"), with extensions to the south in the mountains around Ceres (Anderson & Midgley, 2002). Plants are mostly found near streams and on moist slopes. The soils in the mountains where *R. dentata* grows are derived from sandstones of the Table Mountain Group, and are acidic with low levels of nutrients (van Wyk & Smith, 2001). The weather in these mountains is sunny and pleasant in the summer, but can be nasty in the winter, with periodic cold rains and even the occasional wet snowfall. Light frosts are common at night, but I doubt that *Roridula* could withstand a serious freeze.

I have seen *Roridula* sold as seed, but never as live plants. Perhaps this is because convincing fynbos plants to germinate is something of a black art, so greenhouses rarely have seedling plants in stock. Even so, I have found reasonable results (germination rates of approximately 75%, after several months) using the following prescription. Early autumn is the best time of year to start. First, scarify the seeds, using sandpaper to scrape off a patch of the seed coat. Then plant them, half covered, in a soil mix consisting of 5 parts sphagnum peat moss and 2 parts perlite. When moistened, the seeds exude a coating of brownish mucilage. I do not know what the significance of this behavior is, but the mucilage disappears after a few weeks.

As with many plants of the fynbos, seeds tend to sprout after fire. You can simulate such a fire in various ways, such as sealing the pots in a metal container with a small quantity of burning leaves and twigs. However, non-pyromaniacs will be pleased to learn that the germination cue from fire is more due to the chemicals in smoke than to the heat. The Kirstenbosch botanical garden in South Africa (www.kirstenbosch.co.za) sells smoke-impregnated seed primers, and these are perfect for use with fynbos plants. Seed pots should be kept moist, and placed in a sunny spot that is exposed to warm days and cool nights. Even after all this sandpapering of seeds and setting fire to pots, germination tends to be painfully slow, and it may be months before the first sprout appears. A second smoke treatment may help things along in situations where a seed pot has remained inert for several months. Seedlings can reach flowering size in about three years.

Fynbos vegetation receives most of its rain in winter, and fynbos plants tend to be active primarily during the cooler months. However, *Roridula* grows more or less year-round, with some slowdown in the depths of winter, and with the strongest growth coming in the spring (which is also the time when the plants are most fragrant). Flowers are produced in mid-winter to early-spring (see back cover, inset). Northern Hemisphere growers like myself need not worry about keeping track of the reversed seasons in the Southern Hemisphere when growing plants from South Africa, since the plants adjust to local conditions; *Roridula dentata* plants raised in Connecticut flower in January, having no way of knowing that their relatives in the Cederberg bloom in July.

Roridula plants are not suitable subjects for your average windowsill terrarium or fish-tank-with-shop-lights growth chamber, both because of their size and their environmental needs. Humid, still air and lower light levels are deadly to them. Full sun for most of the day, moderate humidity levels, and consistently moist but never soggy soil seem to be minimum requirements. As with other carnivores, the water used needs to be fairly pure and low in salts. The plants should never stand in water. *Roridula* appreciates large clay pots, with a young-adult plant, 75 cm tall, needing about a 25 cm diameter container. Transplanting early and often promotes vigorous growth, but care is needed when handling the thin, fragile roots. Adult plants are potted in the same peat and perlite mix that I use to sow seeds.

Feeding *Roridula* is problematic: while captive plants ensnare plenty of insects, they can't make use of them without their symbiotic assassin bugs. One German grower reports success in establishing the bugs on cultivated plants (Hartmeyer, 1998), but I don't even want to think about the sort of effort that would be required nowadays to legally collect live assassin bugs, export them from South Africa, and bring them into the United States. So, I just spray their foliage lightly with water-soluble fertilizer at about 1/4 strength every month or two. A high nitrogen, low phosphorous formulation is safest, as fynbos plants are sensitive to excess phosphorous.

Even in a cool, well-ventilated and sunny greenhouse, my plants of *R. dentata* are sometimes subject to fungal infections, which cause branch tips to wilt and turn brown. This seems to be a problem

mostly in the winter, during prolonged spells of cloudy weather, and so far I have not resorted to treatments more drastic than amputating affected stems. The plants fill in again in the Spring, but the recurrence of this problem indicates that there is still something not quite right about the way I treat my *Roridula* plants, even though I have managed to take them from seed to seed. Healthy plants should not get fungal infections. Perhaps they need supplemental light, even in a greenhouse, during the long, dark New England winter.

If one manages to germinate and grow *Roridula* to flowering size, obtaining seeds is not all that difficult. The anthers open via a tiny pore, but will leave a streak of yellow pollen on a piece of dark paper simply brushed by their tips. *Roridula* can be self-pollinated by applying the pollen to the stigma of a flower on the same plant, though seed set seems to be better if two individuals are cross-pollinated. The capsules of *R. dentata* take several months to ripen, and each contains only three seeds, which look exactly like mouse droppings. The capsules open when dry and quickly shed the seeds, which tend to wind up caught in the foliage. Propagation via stem cuttings is possible, but just barely. Rooting is slow and unreliable, whether rooting hormones are used or not, and there is a fine line between keeping the cuttings moist enough not to wilt, but not so moist that they rot. As with adult plants, closed containers and stagnant, damp air are rapidly fatal. Cuttings are best started in a humid but unenclosed situation that receives bright, filtered sunlight. *Roridula dentata* can be an arresting subject for a sunny, Mediterranean greenhouse, growing a meter or more high with viscid, chartreuse and red leaves. However, the difficulty of propagating and growing plants means that it is never likely to be widespread in cultivation.

Literature Cited

Anderberg, A.A., C. Rydin and M. Kallersjo 2002. Phylogenetic relationships in the order Ericales s.l.: analysis of molecular data from five genes from the plastid and mitochondrial genomes. American Journal of Botany 89: 677-687.

Anderson, B. and J.J. Midgley 2002. It takes two to tango but three is a tangle: mutualists and cheaters on the carnivorous plant *Roridula*. Oecologia 132: 369-373.

Anderson, B. and J.J. Midgley 2003a. Digestive mutualism, an alternative pathway in plant carnivory. Oikos 102: 221-224.

Anderson, B. and J.J. Midgley 2003b. Facilitated selfing offers reproductive assurance: a mutualism between a hemipteran and a carnivorous plant. American Journal of Botany 90: 1009-1015.

Cowling, R. and D. Richardson 1995. Fynbos: South Africa's Unique Floral Kingdom. Fernwood Press, Vlaeberg, South Africa.

Darwin, C. 1875. Insectivorous Plants. John Murray, London.

Ellis, A.G. and J.J. Midgley 1996. A new plant-animal mutualism involving a plant with sticky leaves and a resident hemipteran. Oecologia 106: 478-481.

Gardiner, G. and S. Jenkin (eds.) 2004. Fernkloof Nature Reserve Homepage. http://fernkloof.com/other.mv, accessed 10/2004.

Hartmeyer, S. 1998. Carnivory of *Byblis* revisited II: the phenomenon of symbiosis on insect-trapping plants. Carnivorous Plant Newsletter 27: 110-113.

Midgley, J.J. and W.D. Stock 1998. Natural abundance of delta ^{15}N confirms insectivorous habit of *Roridula gorgonias*, despite it having no proteolytic enzymes. Annals of Botany 82: 387-388.

Moore, D.M. 1993. Droseraceae. In: V.H. Heywood, ed. Flowering Plants of the World (updated edition). Oxford University Press, New York.

van Wyk, A.E. and G.F. Smith 2001. Regions of Floristic Endemism in Southern Africa: A Review with Emphasis on Succulents. Umdaus Press, Hatfield, South Africa.

Looking Back: CPN 25 years ago

What is the common name for *Heliamphora*? Larry Mellichamp discussed the confusion when he pointed out that *Heliamphora* is best translated as "sun pitcher," while "*Heleamphora*" would be the spelling of choice if "marsh pitcher" was intended. But as he explained, "However, the correct common name is Marsh Pitcher, and we would certainly be confused if it weren't for the fact that George Bentham, the English botanist who named *Heliamphora* in 1840, meant to call it Marsh Pitcher, and says so in the description!"

ICPS Grant News: Restoration at a North Carolina Mountain Bog

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Keywords: conservation: *Sarracenia jonesii, Sarracenia purpurea.*

Introduction

The Appalachian Mountains in the eastern USA are under assault by human-caused environmental degradation. While habitat destruction in this region is widespread, the mountain bogs are particularly prone to damage. The main kinds of damage include changes to the amount and quality of water flow (i.e. hydrology), fragmentation of habitat by development, invasive species which displace the natives and modify habitat, fire suppression, and—when populations of collectible species become low—poaching.

These bogs include many species of carnivorous plants. Those found nowhere else include the "mountain sweet pitcher plant" we know and love as *Sarracenia jonesii* (or *Sarracenia rubra* subsp. *jonesii*), and a curious variety of decumbent pitcher plant, *Sarracenia purpurea* var. *montana*. These two pitcher plants are rare indeed, with nationwide only about ten sites of *Sarracenia jonesii*, and twenty sites of *Sarracenia purpurea* var. *montana*[1].

One mountain bog in western North Carolina owned and managed by The Nature Conservancy (TNC) is home for both *Sarracenia* species. Over the years this bog has become completely surrounded by development. This has caused harsh changes to its hydrology. The site has had a long history of management, and there has been a great deal of discussion over whether cattle should be allowed on the site; proponents say they would mimic disturbance and decrease competitive vegetation, while critics think they would cause too much damage to the soft and peaty soils. Among *Sarracenia* collectors, this site is famous because it is the source of the anthocyanin-free variety of *Sarracenia jonesii*.[2]

In 2003 I contacted North Carolina TNC staff with a proposition. The ICPS conservation grant program had $2000 available for a focused management project, and we could provide this funding for the management of their mountain bog. After my assurances that the site's location would not be disclosed or publicized, they accepted the grant.

This is a highly strategic grant for the ICPS for three reasons. First, it is a way of supporting TNC's work in an area that is very important to us! Over the last several years, TNC has been shifting its focus to larger, landscape scale sites in order to address issues of habitat fragmentation and other large-scale issues. As a result small "pocket preserves" only a few tens of acres in size are at risk of being downplayed in importance. This grant will encourage TNC to stay active in the mountain bogs. Second, the fact that the site is small means that the ICPS grant—itself rather small—could have a measurable impact, and would not disappear into a huge scale site with no discernable effect. Third, this grant has been a test for cooperation between the ICPS and TNC. Indeed, since it has worked so well, the ICPS has subsequently awarded grants to managers of other TNC sites.

Activities supported by the ICPS grant

Competing bog vegetation, both native and non-native, had grown to such high densities in the North Carolina mountain bog that the carnivorous plants were no longer receiving sufficient light to

[1]There is inconsistency as to how to divide sites, so you will not hear complete agreement as to the precise number of sites for each taxon.

[2]In 2000 I met a TNC scientist who works in North Carolina, and I mentioned to her that the "green" *Sarracenia jonesii* might attract further poachers to the bog. I was astonished when she told me that the last plants had been poached from the site. Although the "green" *Sarracenia jonesii* is readily available in cultivation, it no longer occurs in the wild.

Figure 1: Top row—two images of plots invaded with woody and herbaceous weeds. Second row—Intern Rachel Troyer working, and a clump of *Sarracenia jonesii*. Third row—*Sarracenia jonesii* in sunlight. Images by Rachel Troyer and Andrew Pauly.

thrive. TNC staff had identified four locations in the densely overgrown bog that needed clearing. Each proposed clearing was approximately 30m in diameter. The clearings were covered by as much as 85% or more by non-native species, in particular *Rosa multiflora*, *Microstegium vimineum*, *Lonicera japonica*, *Celastrus orbiculata*, and *Ligustrum sinense* (multifora rose, Japanese stiltgrass, Japanese honeysuckle, oriental bittersweet, and privet). TNC proposed to remove the vegetation by manual pulling or cutting, and then bagging and removing the material to an off-site location so that any seeds would be taken with them. Weeds that had grown to tree size, including vegetation that might resprout from stumps after being cut, would be carefully treated with an herbicide that would not translocate into nontarget vegetation, and which would rapidly degrade into harmless compounds.

I had the opportunity to visit the site before this work had begun. I was struck by how compromised the bog had become. While the TNC staffer showing me around the bog was justly proud of the site (which, incidentally, is home to many other rare organisms, and not just carnivorous plants!), it was clear that the site was not what it used to be. I even wondered if the habitat was at this point a lost cause! (Although I had my camera with me, I couldn't find any carnivorous plants worth

Figure 2: *Sarracenia purpurea* var. *montana*..

photographing—they were all too etiolated and scraggly.)

That summer, TNC employed two interns (Rachel Troyer and Andrew Pauly) to reduce the non-native vegetation cover at the site while trying not to damage the rare native species. At the end of the year, TNC sent the ICPS a report of the work completed at the bog. The interns had concentrated their efforts on four plots, each approximately 30 m in diameter, and managed to reduce the non-native cover to 5% or less (see Figure 1). They worked hard!

Based upon the success of their 2003 work, the conservation grant at the bog was renewed in 2004 for another $2000 to continue their work. At the end of this second year, TNC sent a new report that documented continued success. The interns (Stephanie Grant and Liz Matthews) had increased the number of 30m plots from four to eight, and two of the sites were expanded to approximately 45m in diameter. In addition to the non-natives, the interns removed native woody species such as *Rhododendron*, *Rhus*, and *Smilax* that had encroached on the bog over the years. They also removed native pioneering species such as *Liriodendron tulipifera* and *Acer rubrum* that naturally invade any moist open area. For example, one of the new *Sarracenia* plots had approximately 100% cover of these last two species; by the end of the summer this had been carefully reduced to 70%. At the end of the summer, 25 large garbage bags of vegetative matter had been removed off-site.

Funding in 2005

In the spring of 2005, I had the opportunity to revisit western North Carolina, and this mountain bog in particular. When I viewed the site I was astonished. Where there was once dense woody growth, large sunny clearings now existed and healthy pitcher plants were basking in full sun. The

Figure 3: *Sarracenia jonesii.*

Figure 4: A cleared bog opening, and TNC botanist Dr. Mandy Tu.

transformation was extraordinary! I could see that their work was far from done—various invasive species still occurred on the perimeters of the clearings, waiting for an opportunity to drop seed into the inviting clearings. Furthermore, the rapidly colonizing natives such as *Liriodendron tulipifera* and *Acer rubrum* would crowd out the native carnivores if given a chance. So the work done in 2003-2004 is not enough; continued stewardship is essential to maintain the viability of this site. But the carnivorous plants in this rare mountain bog have a much better chance of survival because of ICPS involvement.

Based on the quality of the stewardship work, I was happy to renew funding in 2005. Indeed, the renewed grant of $2500 is the largest ICPS conservation grant to date. This increased funding will help employ two new interns (Megan Burns and Megan Penrod) for even longer in 2005, so they will be more effective. (I have just heard they added two new weed-free zones to the management of the site.

A round of thanks

Now that the ICPS has been funding conservation work at this bog for three continuous years, I have two sets of thanks to make.

The first set of thanks is to you, the ICPS membership, for your contributions to the conservation program. Every donation to the ICPS conservation program is spent on projects that are carefully selected because they are lean, effective, and have a significant conservation effect. While a portion of the ICPS conservation program is supported by the ICPS annual budget, the majority of its support comes from special donations from the membership. Make your donation today! Since the ICPS is a 501(c)3 nonprofit organization, donations (by USA members) are tax deductible. To make it easier for you, I have even included a special donation form on page 126 in this issue of Carnivorous Plant Newsletter. Photocopy it and include it with your donation.

The second set of thanks is due to the other sources of funding and labor helping to maintain this site. Atlanta Botanical Garden, The Nature Conservancy, North Carolina Resources Commission, US Fish and Wildlife Service, and private individuals have been working to thin and open the woody canopy; this kind of work occurring simultaneously with the ICPS-funded invasive species management and bog-clearing work is doing wonders.

A final set of thanks is to the TNC staff in North Carolina for accepting the grant from the ICPS. They had a string of bad experiences with carnivorous plant enthusiasts trespassing and even poaching from their properties—experiences which continue at various sites to this day. As such, it was a calculated risk on their part to accept involvement from the ICPS. I am glad they took that risk; I think it has paid off well for everyone. The only sad part about this program is that the location and name of the site must stay confidential, and I remind everyone that even though their donations are being used to manage the site, visitation to this privately owned bog is strictly prohibited. The protection of the plants must outweigh our communal desires to see them.

Nepenthes clipeata Conservation

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Keywords: conservation: *Nepenthes clipeata.*

During the ICPS International Conference in San Francisco (2000), I realized it was a marvelous opportunity for conservation. In the same room were such luminaries of the *Nepenthes* worlds of field study, exploration, and nursery propagation as Robert Cantley, Charles Clarke, Chien Lee, and Andreas Wistuba. We formed an impromptu discussion group, and talked about the most imperiled species. It was agreed that a species that was the most likely to become extinct in the wild within the next few decades was *Nepenthes clipeata.* Some estimates suggested that less than a few dozen individual clones remained in the wild. Population pressures were primarily change in habitat, and now that the population was so low, illegal plant collection was likely to deal the final death blow to the plants in the wild.

With extinction a likely outcome, I considered creative conservation options. Since this plant was established in various collections around the world, it was only a matter of time that cultivated plants would represent the bulk (and ultimately the only) genetic record of the *Nepenthes clipeata* genome. A draft ex situ conservation plan was developed, but due to other more pressing issues was allowed to stagnate for a few years.

In 2003, the core people who met in 2000 spontaneously redeveloped interest in this project; the draft conservation plan was recirculated and saw many edits and modifications. James Cokendolpher joined the team (a crucial addition as it turns out). The conservation plan draft was finalized, and it is reprinted in this issue of Carnivorous Plant Newsletter. Read it, and you will learn more about this conservation initiative the ICPS has been working on.

A few comments before you read the conservation plan. First, this initiative does not have any partners based in Indonesia. This is unfortunate, and the ICPS would welcome Indonesian participation. However, the main focus of this initiative is ex situ conservation, so the lack of Indonesian partners should not be misinterpreted as second-party meddling. Second, you will notice that some of the dates are long past, and not all our achievements have occurred on schedule. This is because this plan, like all others, has some goals that are met and others not. Third, I want to note that over the last few years, James Cokendolpher has truly been the powerhouse and engine-room keeping this conservation initiative alive. He alone has been enthusiastic about keeping this activity alive, while we others have been distracted by other pressing concerns. Quite literally, this conservation project owes its vitality to his work.

Nepenthes clipeata Survival Project

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Keywords: conservation: *Nepenthes clipeata*.

Background

The genus *Nepenthes* includes a number of species which are highly endangered because of habitat destruction, fire and collection pressures. Probably no other *Nepenthes* species is as endangered as *Nepenthes clipeata*. First described by Danser (1928), *Nepenthes clipeata* is only known from the vertical cliff faces of Gunung Kelam, in Kalimantan Barat (Clarke, 1997). Explorations of the surrounding mountains have failed to find additional populations (Chien Lee, pers. comm.).

Habitat Stresses

Despite its great rarity, *Nepenthes clipeata* does not grow in any sort of national park or forest reserve.

Prior to 1980, population stresses due to field collection were not significant because few people visited the remote cliff faces of Gunung Kelam. Subsequently, collectors began to visit the mountain frequently and collect large numbers of plants through the 1980s. Local guides, enlisted by tourists, became impressed by the plants and harvested specimens for their villages near the foot of the mountain (Robert Cantley, pers. comm.; Chien Lee, pers. comm.). Such plants rapidly perished and were replaced by new, freshly gathered specimens. Despite these significant pressures, populations of this plant were small but stable as recently as 1990 (Clarke, 1997). No plants were observed during a search for the species in 1993 (J.-P. De Witte, pers. comm.). Simpson (1995) reported that M. Jebb estimated that as few as 15 plants may have remained in the wild by that date.

Conditions have changed within the last decade. Drought conditions in 1997-1998 resulted in significant plant mortality. A new season of drought began early in 2000. Interest in this plant by collectors has increased. The CITES protection status of *Nepenthes clipeata* will be recommended to be upgraded from Appendix II to Appendix I by the CPSG (Carnivorous Plant Specialist Group, of the IUCN's Species Survival Commission). If this is done, it is unclear how this change in status will affect the wild populations of plants. (It is possible it may drive the legal trade of artificially cultivated plants underground, encouraging black market sales and other illegal activities.)

In situ Population Viability

The combination of threats from drought, fire, and collection by visitors and native people is so severe that the plant is likely to become extinct in the wild within 10-20 years (Chien Lee, pers. comm.). In situ conservation, always the preferred option, appears to be unrealistic and unworkable because the single known location for this plant is not likely to be a viable habitat in the long term—repeated burning has caused major community changes to the mountain flora, and these burns are likely to continue. In situ conservation would only be viable if these anthropogenic changes were to stop and the native mountain community was to be restored. There is no governmental interest or financial mechanism for this to happen, so it is likely the mountain sites for *Nepenthes clipeata* will continue to degrade.

Status in Cultivation

In broad terms, *Nepenthes clipeata* specimens in cultivation fall into categories of "white market" and "black market."

White market plants include those that have been legally collected by botanical gardens, or by carnivorous plant horticulturists who usually are interested in introducing plants into in vitro cultivation for rapid propagation. (Note: the in vitro cultivation methods used for *Nepenthes clipeata* is not tissue culture in the usual sense, because tissue culture strictly refers to maintaining a culture of undifferentiated cells and in vitro propagation refers to production of whole plants from cell cultures derived from explants—generally seeds.). White market plants have been collected both as live plants and as seed. Two main categories of white market plants exist:

1)Plants that were collected as live plants or cuttings. While it is difficult to introduce live *Nepenthes* plants into sterile in vitro culture, it is possible.

2)Plants that originated in cultivation. Supposedly, both male and female plants are in cultivation at Munich Botanical Gardens and perhaps elsewhere, and cross-pollination between these plants has occurred on at least one occasion. (The first plants were placed into in vitro culture from Munich seeds in the spring of 1997 (Wistuba, 1998). These plants are now approaching maturity.) However, it is possible that the cross-pollination may have been compromised by pollen from other *Nepenthes* species in the Munich collection, and the genetic purity of the progeny should be viewed cautiously. (*Nepenthes clipeata* is quite distinct morphologically, so fortunately most hybrids should be easily detectable once the plants have matured.) Other fortuitous flowering events will inevitably occur in the future, and such opportunities must be carefully exploited.

It is unknown how many genetically distinct lines of white market plants exist in cultivation, but estimates place the number at three to four (Andreas Wistuba, pers. comm.). Both male and female plants have been grown at the Munich Botanical Gardens in the past.

Black market plants include those that may have been collected illegally and without appropriate export/import documents. It is unknown how many genetically distinct black market plants are presently in cultivation. Some of the apparently white market plants in cultivation may have had their origins as black market plants.

Nepenthes clipeata Survival Project Objectives

It appears that the long-term viability of wild populations of *Nepenthes clipeata* is low. Therefore, it is imperative that ex situ conservation measures be implemented. The *Nepenthes clipeata* Survival Project (*Nc*SP), under the auspices of The International Carnivorous Plant Society, has been devised to maximize the genetic diversity of this species in cultivation.

This document will outline the general intentions of *Nc*SP and its proposed actions.

Short Term Actions

1)Develop a database to track all known *Nepenthes clipeata* strains. Produce and distribute a questionnaire to populate this database with tracking information on as many clones of *Nepenthes clipeata* as possible. Growers in this database will be considered part of a *Nepenthes clipeata* "network".

2)Publicize the issues surrounding the threats to *Nepenthes clipeata*, and how *Nc*SP activities are designed to abate these threats. These articles should be published in as many hobbyist venues as possible, including at least five newsletters and journals, and at least four major web sites.

3)Make in vitro *Nepenthes clipeata* plants easily available worldwide by publicizing sources of legal, ethically obtained and propagated material. While this publicity may increase collector interest in the plant, as long as prices are sufficiently low and supply is sufficiently high, the actions overall should reduce collection pressures. This information should be published in as many hobbyist venues as possible, including at least five newsletters and journals,

Figure 1: Young *Nepenthes clipeata* in *Sphagnum*, the typical growth habit for smaller plants. Notice the unique nature of the tendril attachment to the leaves. Image provided to the ICPS for use by the *Nc*SP, courtesy of Chien Lee.

Figure 2: Mature *Nepenthes clipeata* on Gunung Kelam. Image provided to the ICPS for use by the *Nc*SP, courtesy of Chien Lee.

Figure 3: Mature *Nepenthes clipeata* plants damaged by collectors. Image provided to the ICPS for use by the *Nc*SP, courtesy of Chien Lee.

and at least four major web sites.

4)Develop and widely publish articles on the following aspects of *Nepenthes clipeata* cultivation: Proper cultivation of in vitro and mature plants; collecting/storing pollen, and pollinating *Nepenthes*; collecting and storing seed; how to distinguish pure *Nepenthes clipeata* from its various hybrids; merits of pure *Nepenthes clipeata* vs. hybrids. This information should be published in as many hobbyist venues as possible, including at least five newsletters and journals, and at least four major web sites.

5)Establish a network to store and distribute *Nepenthes clipeata* pollen and/or seed produced. The network should include strains of at least 75% of the plants included in the tracking database.

6)Encourage growers of larger plants to exchange cuttings so adult plants of different clones can be housed together and hopefully increase chances of concurrent flowering. Members of the *Nepenthes clipeata* growers network can be given advice on how to apply for appropriate CITES paperwork to best participate in this program. If appropriate and if in the interest of the success of the overall program, the *Nc*SP will help defray the costs of CITES paperwork.

7)If appropriate, develop and formalize relationships between the *Nc*SP and organizations such as the International Carnivorous Plant Society (ICPS) or the IUCN (especially the Carnivorous Plant Specialist Group).

8)A budget showing expenses and reimbursements should be developed for the *Nc*SP.

Medium Term Actions

1)There are currently no plans to engage in plants of dubious origin. However, The *Nc*SP will remain open to the possibility of accessioning into its databases information about such plants. Similarly, plant stock with dubious origins may be incorporated into *Nc*SP plans if a protocol can be devised that is satisfactory to the *Nc*SP, as well as related conservation groups. If this issue becomes too divisive or problematical, and unnecessarily risks the success of the *Nc*SP, actions relating to it will probably be postponed.

2)Future collections from the wild are probably unjustified. If, however, additional material were collected, only seeds should be removed.

3)Initiate contacting local governing bodies in Kalimantan Barat. While visitation to Gunung Kelam remains low, maintaining some level of vigilance on activities in the area, through communication with locals, would be helpful.

4)Investigate if other plants in the area of Kalimantan Barat are endangered and what efforts are underway to support their conservation. Joint proposals should be sought with such groups.

5)It may be useful to place tissue samples from identified pure or hybrid strains of *N. clipeata* plant into DNA preservatives (ultracold storage, DMS, 100% ethanol, etc.) as a basis for future studies.

6)Identify organizations such as botanical gardens, horticultural societies, and conservation organizations that would be willing to cooperate with the *Nc*SP. Investigate sources of funding for these initiatives. Ron Gagliardo (Atlanta Botanical Gardens), Ruth Kiew (Singapore), Kath King (Kew) might be appropriate initial contacts.

7)Make arrangements for the storage of pollen and fertilized seeds in cryogenic storage. Seeds are to be deposited with the understanding that a set number of seeds can be removed by the project at anytime and that the storage facility will notify the project at least 3 months in advance if they are no longer able to care for the storage of the seeds. Agreements to be established for 50 or 100 years. At least two facilities should be sought on different continents (likely to be USA, Europe, and possibly Japan). Arrangements have already been established for receipt of seeds and pollen and temporary storage (at -80°C) at Texas Tech University, Lubbock, Texas (via James Cokendolpher) until other arrangements for long-term storage have been made.

Long Term Actions

1)Reintroduction plans could be developed and implemented. A useful starting point for this kind of difficult, expensive, and risky project would be the work of Veena Tandan (Department

of Zoology, North Eastern Hill University, Shillong 793022, Meghalaya) (Akula, 1996). Professor Katsuhiko Kondo (Japan) has worked with a somewhat similar project, involving *Aldrovanda vesiculosa* in Japan, and could be a good resource in this kind of project.

2)Identify individuals that could conduct research if funding were available which could contribute to the survival of this and other *Nepenthes* species. Further, assist these individuals in locating funds for such projects. Examples of such projects might be:

i)Investigate karyology for determining sexes of young plants

ii)Factors influencing blooming

iii)Factors influencing apomixis

iv)Method for preparing meristem tissue culture

v)Effects of long-term cryogenic storage on pollen and fertilized seed

vi)Establish protocol for DNA testing for culling hybrids from breeding program and establish limits of populations

vii)Investigations on minimal numbers of unrelated plants needed for survival in wild

viii)Investigate population viability of *Nepenthes clipeata*—determine minimum number of plants needed to ensure long term viability.

Measures of Success

To determine if *Nc*SP is reaching its goals, the following timetable is proposed for the next two years.

1)By March 2004: Develop database for tracking clones and larger plants of *N. clipeata* in culture.

2)By June 2004: Make arrangements with at least 2 (one in USA, one in Europe) cryogenic storage facilities to store fertilized seeds and pollen.

3)By June 2004: Submit for publication (on WWW and all major carnivorous plant society newsletters/journals) notices of the database and project activities requesting help/data.

4)By September 2004: Prepare web pages on cultivation and propagation.

5)By January 2005: Establish at least 5 distinct clones of *N. clipeata* in at least 6 different botanical gardens (2 in USA, 2 in Europe, 2 in Australasia).

Financial Support and Future Programs

At present, *Nc*SP activities are being supported by the volunteer work of the *Nc*SP founding members. In the future, financial support will be required to pay for its activities.

1)Some funds to support the *Nc*SP can be provided by the ICPS conservation fund. This discretionary fund is managed by the ICPS Director of Conservation.

2)Future corporate or private support may be sought for the *Nc*SP.

3)Nurseries may be encouraged to contribute an as-yet undetermined amount per *Nepenthes clipeata* plant sold.

The *Nc*SP is a pilot program. If it is successful (as shown by its measures of success), additional, similar programs may be launched.

Bibliography

Akula, D. 1996. Re: *Nepenthes*, plant-tc listserve posting, http://www.agro.agri.umn.edu/plant-tc/listserv/1996/log9610/msg00050.html.

Clarke, C. 1997. *Nepenthes* of Borneo. Natural History Publications, Kota Kinabalu, Sabah, xii + 207 pp.

Danser, B.H. 1928. The Nepenthaceae of the Netherland Indies, Bulletin de Jardin de Botanique, Buitenzorg, Serie III, 9(3-4): 249-348.

Simpson, R.B. 1995. *Nepenthes* and conservation. Curtis's Bot. Mag. 12: 111-118-

Wistuba, A. 1998. Re:*N. clipeata* question. CP Mailing List Archives, http://www2.labs.agilent.com/botany/cp/list/cp98all.d/0075.htm.

Mike Howlett (mhowlett@hcp4.net, http://www.hcp4.net/jones) wrote about a restoration project he is working on in Texas, USA: The twelve-acre Watson Pinelands Preserve is a privately-owned site located near Warren, adjacent to the Big Thicket National Preserve. The owner, Ms. Geraldine Watson, has made it her mission to assemble an amazing display of native East Texas flora. Visitors can wander from beech (*Fagus grandifolia*) uplands through savannahs of longleaf pines (*Pinus palustris*) and many species of ferns, and ultimately to my personal favorite—sphagnum bogs brimming with native orchids, lilies and, of course, carnivorous plants. *Sarracenia alata, Drosera brevifolia, D. capillaris, Pinguicula pumila* and *Utricularia subulata* all call this oasis home. The preserve is open for anyone to visit without charge.

Unfortunately, several years ago someone (we aren't sure who) introduced *Sarracenia leucophylla* into the bog. The introduction of this plant went unnoticed. The result is a multitude of unwanted hybrid *S.* × *areolata* on the preserve. With Ms. Watson's permission, in April 2005 I removed all the *Sarracenia* exhibiting *S. leucophylla* characteristics. These plants were offered to CP list serve subscribers in return for donations to the preserve.

The work at the preserve is not finished, and any donations would be very appreciated! For example, we need to rebuild and widen the boardwalk to allow safer access to the bog area. Even a donation of $20 would help us along! If you wish to donate to this worthwhile cause you may send funds, payable to either me (Mike Howlett) or Geraldine Watson, to Mike Howlett, Jesse H. Jones Park & Nature Center, 20634 Kenswick Dr., Humble, TX 77338 USA.

Figure 1: *Sarracenia* flowers at Watson Pinelands Preserve. Even in this black and white photograph, you might be able to discern the darker-colored, hybrid flowers in the very center of the image. Photograph by Scott Weitzenhoffer.

Eric Schlosser (eric.schlosser@gmx.de) wrote about his observations in the Azores: This remote archipelago of nine volcanic islands rises from the depth of the north-Atlantic ridge, and possesses no native carnivorous plant species.

While hiking near Furnas on São Miguel during a presumably carnivorous plant-free vacation, I was quite shocked to discover a small patch of sundews dwelling on a steep road embankment (N37.7704°, W25.3289°). The *Drosera* was clearly of South African relationship, most likely *D. aliciae* imported by flower shops. The cloud-embraced mountains host blanket bogs covered with red and green *Sphagnum* moss, acidic seeps, mires at high plateaus, and thus ample habitat for carnivorous plants. Even though I left the plants unhurt, I highly recommend removal of this potentially invasive species by qualified personnel as long as it is an isolated occurrence.

Please stop infesting habitats, most of which are threatened themselves, with non-indigenous species. The potential ecological and political damage is not worth the joy of seeing your favourite plants naturalise in the field.

Barry Rice (barry@carnivorousplants.org) has information about the effects of Hurricane Katrina on Mississippi and Louisiana. The storm surge and rainfall has resulted in the flooding of many carnivorous plant habitats, especially coastal populations—those who know the area will be agog to learn that the storm surge flooded even Highway 90 in the Ocean Springs, Mississippi area. Some *Sarracenia alata* sites were inundated with up to 3m (10 feet) of water for more than four hours. However, these habitats and their species seem to have a certain innate resilience to the occasional inundation with salt water. The high veloeity winds have contributed to many trees being killed, with some sites having up to 80-90% of the forest cover gone. Yet, on long timescales, this process is arguably a natural event, and sun-loving species like carnivorous plants could actually benefit from the process. What is not, however, a natural process is the extensive fragmentation that has occurred because of human development. When the habitat was unfragmented, there were far more populations of plants that could contribute to the overall survival of the species. Now, with habitats so reduced that populations of carnivorous plants are so modified, the effects of major deforestation events like Hurricane Katrina are unclear. Another concern that conservation workers in the area have is that non-native species, particularly *Sapium sebiferum* (Chinese tallowtree) could spread to new habitats opened up from the deforestation.

The flooding of New Orleans, while yet another layer of devastation on the disaster, does not have any significant impacts upon carnivorous plants—the impacts on the environment from that are more confined to marine and brackish environments, and will take a long time to understand and assess.

Partly as a response to this event, and also because it fits well with strategic plans, the International Carnivorous Plant Society's conservation program is awarding a $2000 conservation grant to the Louisiana program of The Nature Conservancy to help in the repairs and clean-up at the Abita Creek Preserve, a site in southern Louisiana with impressive populations of carnivorous plants. This site will need some work to recover from the tree damage. If you want to make an extra contribution to post-storm cleanup in Louisiana and Mississippi, see the boxed notice on page 126.

Isao Takai (isaot4cp@bk.iij4u.or.jp) sent some images of his *Byblis filifolia* plants. (Those who attended the IPS/ICPS conference in Japan might have seen some of these plants.) While Carnivorous Plant Newsletter rarely publishes photographs without supporting articles, these photographs are really spectacular. Isao is truly working magic with this species.

Figure 2: Rows of Isao's *Byblis filifolia* plants with pink flowers, the normal mauve flowers, and white flowers. A row of *Byblis liniflora* plants is behind the row of white-flowered plants.

Figure 3: Two giant clones: pinkish-mauve flowers (left), white flowers (right). There are only about seven heavily branching plants in each pot! The foreground plant is a normal sized white-flowered clone. (That is Isao's wife in the background.)

Figure 4: A closer view of the normal sized, white-flowered plants. The descending leaves act like tripod legs and support the plant.

Figure 5: Color variation in *Byblis filifolia* petals: normal pinkish-mauve, deep pinkish-mauve, lilac-mauve, and white.

Tax Deductions and the ICPS

I would like to remind all our members that the ICPS is recognized by the USA Internal Revenue Service as a nonprofit 501(c)3 organization. Therefore, charitable contributions to the ICPS by USA members are tax deductible.

Should you donate to the ICPS? My resounding answer is yes! Consider some of the accomplishments by the ICPS in conserving rare carnivorous species. The ICPS has funded conservation programs designed to help *Sarracenia purpurea* var. *montana* in Georgia and North Carolina, *Sarracenia jonesii* in North Carolina, *Sarracenia oreophila* in Alabama, Georgia, and North Carolina, and *Nepenthes clipeata* in collections. The seedbank's distribution of threatened and endangered carnivorous plant seed is also an offshoot of the ICPS conservation program. The ICPS is also involved in the care of sites housing other *Darlingtonia*, *Drosera*, *Pinguicula*, and *Utricularia*.

So support the ICPS with a tax-deductible donations, as I have done. Write out your check to "ICPS Conservation Program" and send it to the ICPS. Save a stamp and send it with your membership renewal! And if you want to choose what conservation initiative you would most like to support, return your payment with a photocopy of this page, indicating your choice. If possible, I will make sure that your check helps fund your favorite program!

Sincerely,

Barry Rice
ICPS Director of Conservation Programs

- ☐ Support bog clearing work in North Carolina!
- ☐ Support carnivorous plant habitat restoration in Louisiana and Mississippi after Hurricane Katrina!
- ☐ Support bog savannah burns in Alabama!
- ☐ Support carnivorous plant work by Atlanta Botanical Gardens!
- ☐ Spend the money on these or other conservation programs, as needed!

Index of Contributors

Referees/Correspondents:
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